CHAPTER 4

Water Reuse Regulations and Guidelines in the U.S.

Most reuse programs operate within a framework of regulations that must be addressed in the earliest stages of planning. A thorough understanding of all applicable regulations is required to plan the most effective design and operation of a water reuse program and to streamline implementation.

Currently, there are no federal regulations directly governing water reuse practices in the United States. Water reuse regulations have, however, been developed by many of the states. These regulations vary considerably from state to state. Some states, such as Arizona, California, Florida, and Texas, have developed regulations that strongly encourage water reuse as a water resources conservation strategy. These states have developed comprehensive regulations specifying water quality requirements, treatment processes, or both for the full spectrum of reuse applications. The objective in these states is to derive the maximum resource benefits of the reclaimed water while protecting the environment and public health. Some states have developed water reuse regulations with the primary intent of providing a disposal alternative to discharge to surface waters, without considering the management of reclaimed water as a resource.

This section provides an inventory of the various state water reuse regulations throughout the U.S. and introduces recommended guidelines that may aid in the development of more comprehensive state or even federal standards for water reuse. Water reuse outside the U.S. is discussed in Chapter 8.

4.1 Inventory of Existing State Regulations

The following inventory of state reuse regulations is based on a survey of all states conducted specifically for this document. Regulatory agencies in all 50 states were contacted by mail in September 1990 and asked to provide information concerning their current regulations governing water reuse. After follow-up contact, all 50 states responded to the request for information. All of the information presented in this section is considered current as of March 1992.

Also as part of the survey, all states were asked to provide an inventory of their existing reuse projects. The results indicated there are approximately 1,900 reuse projects currently operating throughout 34 states. This represents a significant increase since the survey conducted in 1979 as part of the original 1980 Guidelines (EPA, 1980b), when only 540 reuse projects were reported throughout 24 states.

Only California and Florida compile comprehensive inventories of reuse projects by types of reuse application. These inventories are available from the California Water Resources Control Board in Sacramento and the Florida Department of Environmental Regulation in Tallahassee, respectively.

The U.S. Geological Survey compiles an estimate of national reclaimed water use every 5 years in their publication *Estimated Use of Water in the United States.* The 1990 inventory estimated that approximately 900 mgd of the effluent discharged in the U.S. was used for beneficial purposes.

Most states do not have regulations that cover all potential uses of reclaimed water. Arizona, California, Florida, Texas, Oregon, Colorado, Nevada, and Hawaii have extensive regulations or guidelines that prescribe requirements for a wide range of end uses of the reclaimed water. Other states have regulations or guidelines which focus upon land treatment of wastewater effluent, emphasizing additional treatment or effluent disposal rather than beneficial reuse, even though the effluent may be used for irrigation of agricultural sites, golf courses, or public access lands.

Based on the inventory, current regulations may be divided into the following reuse categories:

- Unrestricted urban reuse - irrigation of areas in which public access is not restricted, such as parks, playgrounds, school yards, and residences; toilet flushing, air conditioning, fire protection, construction, ornamental fountains, and aesthetic impoundments.

- Restricted urban reuse - irrigation of areas in which public access can be controlled, such as golf courses, cemeteries, and highway medians.

- Agricultural reuse on food crops - irrigation of food crops which are intended for direct human consumption, often further classified as to whether the food crop is to be processed or consumed raw.

- Agricultural reuse on non-food crops - irrigation of fodder, fiber, and seed crops, pasture land, commercial nurseries, and sod farms.

- Unrestricted recreational reuse - an impoundment of water in which no limitations are imposed on body-contact water recreation activities.

- Restricted recreational reuse - an impoundment of reclaimed water in which recreation is limited to fishing, boating, and other non-contact recreational activities.

- Environmental reuse - reclaimed water used to create artificial wetlands, enhance natural wetlands, and to sustain stream flows.

- Industrial reuse - reclaimed water used in industrial facilities primarily for cooling system make-up water, boiler-feed water, process water, and general washdown.

Table 26 provides an overview of the current water reuse regulations and guidelines by state and by reuse category. The table identifies those states that have regulations, those with guidelines and those states which currently do not have either. Regulations refer to actual rules that have been enacted and are enforceable by governmental agencies. Guidelines, on the other hand, are not enforceable but can be used in the development of a reuse program.

As of March 1992, 18 states had adopted regulations regarding the reuse of reclaimed water, 18 states had guidelines or design standards, and 14 states had no regulations or guidelines. In states with no specific regulations or guidelines on water reclamation and reuse, programs may still be permitted on a case-by-case basis.

The majority of current state regulations and guidelines pertain to the use of reclaimed water for urban and agricultural irrigation. At the time of the survey, the only states that had specific regulations or guidelines regarding the use of reclaimed water for purposes other than irrigation were Arizona, California, Florida, Hawaii, Nevada, Oregon, Colorado, South Dakota, Texas, and Utah.

Table 27 shows the number of states with regulations or guidelines for each type of reuse. The category of unrestricted urban reuse has been subdivided to indicate the number of states that have regulations pertaining to urban reuse not involving irrigation. Florida, Texas, and Hawaii are the only states that have regulations pertaining to the use of reclaimed water for toilet flushing. Florida, Texas, and Hawaii all require a high degree of treatment prior to use for toilet flushing. In addition, Texas requires that the reclaimed water be dyed blue prior to distribution for use as toilet flush water, while Florida requires that reclaimed water may only be used for toilet flush water where residents do not have access to the plumbing system for repairs or modifications.

Florida and Hawaii are currently the only states with regulations pertaining to the use of reclaimed water for fire protection, while Nevada, Florida, Hawaii, and Oregon have regulations for the use of reclaimed water for construction purposes. The use of reclaimed water for landscape or aesthetic impoundments is regulated in the states of California, Florida, Hawaii, Oregon, Texas, Colorado, and Nevada. Hawaii is currently the only state with regulations or guidelines pertaining to the use of reclaimed water for street cleaning.

At this time, Arizona, California, Colorado, Hawaii, Nevada, Oregon, and Texas have regulations or guidelines pertaining to recreational reuse, while Arizona, Florida, and South Dakota have regulations or guidelines pertaining to environmental reuse utilizing natural or artificial wetlands. Reclaimed water used for industrial purposes is currently regulated in Arizona, Hawaii, Nevada, Oregon, Texas and Utah.

Summaries of each state's regulatory or guideline requirements for each type of reuse are given in Appendix A in Tables A-1 through A-8. The regulations pertaining to each type of reuse are divided into the following categories:

- Reclaimed water quality and treatment requirements

Table 26. Summary of State Reuse Regulations and Guidelines

STATE	Regulations	Guidelines	No Regulations or Guidelines (2)	Unrestricted Urban Reuse	Restricted Urban Reuse	Agricultural Reuse Food Crops	Agricultural Reuse Non-Food Crops	Unrestricted Recreational Reuse	Restricted Recreational Reuse	Environmental Reuse	Industrial Reuse
Alabama		•					•				
Alaska			•								
Arizona	•			•	•	•	•	•	•	•	•
Arkansas		•		•	•	•	•				
California	•			•	•	•	•	•	•		
Colorado		•		•	•	•	•	•	•		
Connecticut			•								
Delaware		•		•	•		•				
Florida	•			•	•	•	•			•	
Georgia		•		•	•		•				
Hawaii		• (1)		•	•	•	•		•		•
Idaho	•			•	•	•	•				
Illinois	• (1)			•	•		•				
Indiana	•					•	•				
Iowa			•								
Kansas		•		•	•	•	•				
Kentucky			•								
Louisiana			•								
Maine			•								
Maryland		•			•		•				
Massachusetts			•								
Michigan	•					•	•				
Minnesota			•								
Mississippi			•								
Missouri	•				•		•				
Montana		•		•	•	•	•				
Nebraska		•			•		•				
Nevada		• (1)		•	•	•	•	•	•		•
New Hampshire			•								
New Jersey	•						•				
New Mexico		•		•	•	•	•				
New York		•					•				
North Carolina	•				•						
North Dakota		•					•				
Ohio			•								
Oklahoma		•			•		•				
Oregon	•			•	•	•	•	•	•		•
Pennsylvania			•								
Rhode Island			•								
South Carolina		•		•	•		•				
South Dakota		•		•	•		•			•	
Tennessee	•			•	•		•				
Texas	•			•	•	•	•		•		•
Utah	•			•	•	•	•				•
Vermont	•						•				
Virginia			•								
Washington		•		•	•	•	•				
West Virginia	•					•	•				
Wisconsin	•						•				
Wyoming	•			•	•	•	•				

(1) Draft or Proposed
(2) Specific regulations on reuse have not been adopted; however, reclamation may be approved on a case-by-case basis.

Table 27. Number of States with Regulations or Guidelines for Each Type of Reuse Application

Type of Reuse	Number of States
Unrestricted Urban	22
Irrigation	22
Toilet Flushing	3
Fire Protection	2
Construction	4
Landscape Impoundment	7
Street Cleaning	1
Restricted Urban	27
Agricultural (Food Crops)	19
Agricultural (Non-Food Crops)	35
Unrestricted Recreational	5
Restricted Recreational	7
Environmental (Wetlands)	3
Industrial	6

- Reclaimed water monitoring requirements
- Treatment facility reliability
- Storage requirements
- Application rates
- Groundwater monitoring
- Setback distances (buffer zone)

4.1.1 Reclaimed Water Quality and Treatment Requirements

Requirements for water quality and treatment receive the most attention in state reuse regulations. States which have water reuse regulations or guidelines have set standards for reclaimed water quality and/or specified minimum treatment requirements. Generally, where unrestricted public exposure is likely in the reuse application, wastewater must be treated to the highest degree prior to its application. Where exposure is not likely, however, a lower level of treatment is usually accepted.

The most common parameters for which water quality limits are imposed are biochemical oxygen demand (BOD), total suspended solids (TSS), and total or fecal coliform counts. Total and fecal coliform counts are generally used as indicators to determine the degree of disinfection. A limit on turbidity is usually specified to monitor the performance of the treatment facility.

4.1.1.1 Unrestricted Urban Reuse

Unrestricted urban reuse involves the use of reclaimed water where public exposure is likely in the reuse application, thereby necessitating the highest degree of treatment. Review of existing regulations, however, reveals a wide variation in treatment and water quality requirements for unrestricted urban reuse. For example, Utah requires advanced treatment with BOD not to exceed 10 mg/L and TSS not to exceed 5 mg/L. In addition, total coliform is not to exceed 3/100 mL at any time. South Dakota, on the other hand, requires only secondary treatment with disinfection with the median total coliform count not to exceed 200/100 mL.

In general, all states with regulations require a minimum of secondary or biological treatment prior to unrestricted urban reuse, with most requiring disinfection. However, many states require additional levels of treatment. The states of Idaho, California, and Colorado require oxidation, coagulation, clarification, filtration, and disinfection prior to unrestricted urban reuse. Other states, such as Arizona and Texas, do not specify the type of treatment processes required, but only set limits on the reclaimed water quality.

Where specified, limits on BOD range from 5 mg/L to 30 mg/L. Texas requires that BOD not exceed 5 mg/L (monthly average) except when reclaimed water is used for landscape impoundments, in which case BOD is limited to 10 mg/L. Georgia, on the other hand, requires that BOD not exceed 30 mg/L prior to unrestricted urban reuse. Limits on TSS vary from 5 mg/L to 30 mg/L. Both Utah and Florida require that TSS not exceed 5 mg/L, with Florida requiring that the TSS limit be achieved prior to disinfection and not be exceeded in any one sample. Georgia requires that TSS not exceed 30 mg/L. For those states that do not specify limitations on BOD or TSS, a particular level of treatment is usually specified.

Average fecal and total coliform limits for those states that limit coliforms range from non-detectable to 200/100 mL. Higher single sample fecal and total coliform limits are noted in several state regulations. Florida requires that 75 percent of the fecal coliform samples taken over a 30-day period be below detectable levels, with no single sample in excess of 25/100 mL. Conversely, South Dakota requires a medial total coliform count not to exceed 200/100 mL. Utah requires that no single sample exceed a total coliform count of 3/100 mL for unrestricted urban reuse, while Texas and Arizona require that no single fecal coliform count exceed 75/100 mL.

Where specified, limits on turbidity range from 2 to 5 NTU. For example, Oregon requires that the turbidity not exceed 2 NTU (24-hour mean) and California requires

the turbidity not exceed 2 NTU. Arizona requires that turbidity not exceed 5 NTU. Florida requires continuous on-line monitoring of turbidity; however, no limit is specified.

At this time, Arizona and Hawaii are the only states that have set limits on certain pathogenic organisms for unrestricted urban reuse. In Arizona, the pathogens include enteric viruses and Ascar*is lumbricoides* (roundworm) eggs. Arizona's allowable limit for the enteric virus is 125 plaque forming units (pfu)/40 L and none detectable for *Ascaris lumbricoides*. In Hawaii, the pathogens are enteric viruses and the allowable limit is less than 1 pfu/40 L. South Carolina requires that viruses be monitored but does not specify the type of viruses to be monitored or any limits.

4.1.1.2 Restricted Urban Reuse

Restricted urban reuse involves the use of reclaimed water where public exposure to the reclaimed water is controlled; therefore, treatment requirements may not be as strict as in unrestricted urban reuse. Review of existing regulations, again, reveals a wide variation in treatment and water quality requirements for restricted urban reuse. Only 12 of 22 states that regulate both categories adjust requirements downward for this category. Five states do not permit unrestricted urban reuse, but only allow restricted urban reuse. For example, Utah requires advanced treatment with BOD not to exceed 10 mg/L and TSS not to exceed 5 mg/L. In addition, total coliform is not to exceed 3/100 mL at any time. New Mexico, on the other hand, requires that the reclaimed water be adequately treated and disinfected with the fecal coliform count not to exceed 1,000/100 mL.

In general, most states with regulations require a minimum of secondary or biological treatment followed by disinfection prior to restricted urban reuse. Again, many states require additional levels of treatment, with California, Idaho, and Colorado requiring disinfection and biological oxidation prior to restricted urban reuse. South Carolina requires secondary treatment with disinfection, chemical addition, and filtration, except for golf course irrigation where filtration and chemical addition are not required. As in unrestricted urban reuse, Arizona does not specify the type of treatment processes required, but only sets limits on the reclaimed water quality.

Where specified, limits on BOD range from 5 mg/L to 30 mg/L. South Carolina requires that BOD not exceed 5 mg/L (monthly average), while Delaware, Hawaii, Maryland, Georgia, and Texas require that BOD not exceed 30 mg/L prior to restricted urban reuse. Limits on TSS vary from 5 mg/L to 90 mg/L. Utah, Florida, South Carolina, and North Carolina require that TSS not exceed 5 mg/L, while Maryland requires that TSS not exceed 90 mg/L. As in unrestricted urban reuse, for those states that do not specify limitations on BOD or TSS, a particular level of treatment is usually specified.

Average fecal coliform limits for those states that limit fecal coliforms range from non-detectable to 1,000/100 mL, with some states allowing higher single sample fecal coliform limits. As in unrestricted urban reuse, Florida requires that 75 percent of the fecal coliform samples taken over a 30-day period be below detectable levels, with no single sample in excess of 25/100 mL. New Mexico, on the other hand, requires the fecal coliform count not to exceed 1,000/100 mL. North Carolina requires that the maximum fecal coliform level not exceed 1/100 mL, while Arizona requires that no single fecal coliform count exceed 1,000/100 mL.

Nevada is the only state that has set a limit on turbidity for restricted urban reuse, requiring that no single sample exceed a turbidity of 5 NTU.

4.1.1.3 Agricultural Reuse - Food Crops

The use of reclaimed water for irrigation of food crops is prohibited in some states, while others allow irrigation of food crops with reclaimed water only if the crop is to be processed and not eaten raw. Most states require a high level of treatment when reclaimed water is used for edible crops, especially those which are consumed raw. As in other reuse applications, however, existing regulations on treatment and water quality requirements vary from state to state and depend largely on the type of irrigation employed and the type of food crop being irrigated. For example, for foods consumed raw, Colorado requires that the reclaimed water be disinfected and biologically oxidized when surface irrigation is used, with the mean total coliform count not to exceed 2.2/100 mL. When spray irrigation is utilized, Colorado requires that the reclaimed water be disinfected, oxidized, coagulated, clarified, and filtered, with the mean total coliform count not to exceed 2.2/100 mL. For processed foods, Colorado requires only disinfection and oxidation regardless of the type of irrigation, with the total coliform count not to exceed 23/100 mL.

Treatment requirements range from primary treatment in Arkansas for irrigation of processed food crops, to biological oxidation, coagulation, clarification, filtration, and disinfection in California, Colorado, and Idaho.

Where specified, limits on BOD range from 20 mg/L to 30 mg/L. Florida requires that the annual average CBOD not exceed 20 mg/L after secondary treatment with filtration and high level disinfection, while Texas requires that the BOD not exceed 30 mg/L (monthly average) when the

reclaimed water is treated using a pond system. In Texas, spray irrigation is not permitted on foods to be consumed raw. Limits on TSS vary from 5 mg/L to 25 mg/L. Florida requires that TSS not exceed 5 mg/L in any one sample prior to disinfection, while Utah requires that the TSS not exceed 25 mg/L (monthly average). In Florida, direct contact of reclaimed water on edible crops that are not processed is prohibited, while Utah only considers the irrigation of particular food crops on a case-by-case basis and does not allow the use of spray irrigation.

Average fecal and total coliform limits for those states that limit coliforms range from non-detectable to 2,000/100 mL. Florida requires that 75 percent of the fecal coliform samples taken over a 30-day period be below detectable levels, with no single sample in excess of 25/100 mL. Conversely, Utah requires a median total coliform count of 2,000/100 mL. Again, some states allow higher single sample coliform counts. California and Oregon require that no single sample exceed a total coliform count of 23/100 mL, while Arizona requires that no single fecal coliform count exceed 2,500/100 mL for irrigation of food crops that are to be processed.

Where specified, limits on turbidity range from 1 to 3 NTU. For example, Arizona requires that the turbidity not exceed 1 NTU for reclaimed water irrigated on food crops to be consumed raw, while Texas requires that turbidity not exceed 3 NTU.

At this time, Arizona and Hawaii are the only states that have set limits on certain pathogenic organisms for agricultural reuse of nonfood crops. In Arizona, the pathogens include: enteric viruses, Entamoeba histolytica, Giardia *lamblia*, and *Ascaris lumbricoides*. The limits on these pathogenic organisms apply to irrigation of unprocessed food crops. The allowable limit for all of these organisms in Arizona, with the exception of enteric viruses, is none detectable. The allowable limit for enteric viruses is 1 pfu/40 L. In Hawaii, when reclaimed water is used to irrigate root food crops or food crops with the above-ground edible portion that touches the ground, the pathogens that have set limits include: enteric viruses, viable oocysts, *Cryptosporidium*, and cysts of *Giardia* and *Entamoeba*. Hawaii's guidelines state that these organisms, with the exception of enteric viruses, should be non-detectable. The allowable limit for enteric viruses is 1 pfu/40 L.

4.1.1.4 Agricultural Reuse - Nonfood Crops

The use of reclaimed water for agricultural irrigation of nonfood crops presents the least opportunity of human exposure to the water, resulting in less stringent treatment and water quality requirements than other forms of reuse. Treatment requirements range from primary treatment in Arkansas, California, and New Mexico, to secondary treatment with disinfection in the majority of the states with regulations. Arkansas, California and New Mexico also require disinfection when irrigating pastures for milking animals.

Where specified, limits on BOD range from 20 mg/L to 75 mg/L. Florida requires that the annual average CBOD not exceed 20 mg/L after secondary treatment and basic disinfection. Texas also requires that BOD not exceed 20 mg/L when using a treatment system other than a pond system. Delaware and Georgia require that the BOD not exceed 75 mg/L during peak flow conditions and 50 mg/L during average flow conditions. Limits on TSS vary from 10 mg/L to 90 mg/L. Florida requires that the annual average TSS not exceed 20 mg/L except when a subsurface application is used, in which case the single sample TSS limit is 10 mg/L. Maryland, on the other hand, requires that TSS not exceed 90 mg/L.

Average fecal and total coliform limits for those states that limit coliforms range from 2.2/100 mL to 2,000/100 mL. Nevada requires that the median fecal coliform count not exceed 2.2/100 mL for spray irrigation sites with no buffer zone. California, Hawaii, and Oregon all require that the median total coliform count not exceed 23/100 mL. Conversely, Utah requires that the total coliform count not exceed 2,000/100 mL. Some states allow higher single sample coliform counts. Nevada requires that no single sample exceed a fecal coliform count of 23/100 mL for spray irrigation sites with no buffer zone, while Arizona requires that no single fecal coliform count exceed 4,000/100 mL.

At this time no states have any required limits on turbidity for reclaimed water used for agricultural reuse on nonfood crops.

As for pathogenic organisms, Arizona calls for no detectable common large tapeworms when reclaimed water is used for irrigation of pastures.

4.1.1.5 Unrestricted Recreational Reuse

As with unrestricted urban reuse, unrestricted recreational reuse involves the use of reclaimed water where public exposure is likely, thereby necessitating the highest degree of treatment. Only five states (Arizona, Colorado, California, Nevada, and Oregon) have regulations pertaining to unrestricted recreational reuse. Nevada requires secondary treatment with disinfection, while California and Colorado require disinfection, biological oxidation, coagulation, clarification, and filtration. None of these five states have set limits on BOD or TSS; however, California, Oregon, and Colorado all require that the median total coliform count not exceed

2.2/100 mL, with no single sample to exceed 23/100 mL. Nevada requires that the median fecal coliform count not exceed 2.2/100 mL, with no single sample to exceed 23/100 mL, while Arizona requires that the median fecal coliform count not exceed 200/100 mL, with no single sample to exceed 800/100 mL.

Limits on turbidity range from 1 NTU in Arizona to 2 NTU in California, Nevada, and Oregon. Colorado has no limit on turbidity.

At this time, Arizona is the only state which has set limits on certain pathogenic organisms for unrestricted recreational reuse. The pathogens include: enteric virus, Entamoeba histolytica, Giardia lamblia, and *Ascaris lumbricoides*. The allowable limit for all of these organisms, with the exception of enteric virus, is none detectable. The allowable limit for the enteric virus is 1 pfu/40 L.

4.1.1.6 Restricted Recreational Reuse

State regulations regarding treatment and water quality requirements for restricted recreational reuse are generally less stringent than for unrestricted recreational reuse since the public exposure to the reclaimed water is less likely. Only seven states (Arizona, Colorado, California, Hawaii, Nevada, Oregon, and Texas) have regulations pertaining to restricted recreational reuse. With the exception of Arizona, all of the states with regulations basically require secondary treatment with disinfection. Arizona does not specify treatment process requirements.

Texas is the only state with a limit on BOD, which is set at 10 mg/L. None of the seven states has set limits on TSS. California, Oregon, and Colorado require that the median total coliform count not exceed 2.2/100 mL. Oregon also requires that no single total coliform sample exceed 23/100 mL. Nevada requires that the median fecal coliform count not exceed 2.2/100 mL, with no single sample exceeding 23/100 mL, while Texas requires that the fecal coliform count not exceed 75/100 mL. Hawaii requires that the mean total coliform count not exceed 23/100 mL, with no two consecutive samples exceeding 240/100 mL. Arizona, on the other hand, requires the median fecal coliform count not to exceed 1,000/100 mL, with no single sample exceeding 4,000/100 mL.

Limits on turbidity range from 3 NTU in Nevada and Texas to 5 NTU in Arizona. Colorado, California, and Oregon have no limits on turbidity.

At this time, Arizona is the only state which has set limits on certain pathogenic organisms for restricted recreational reuse. The pathogens include enteric viruses and *Ascaris lumbricoides*. The allowable limit for enteric viruses is 125/40 L and none detectable for *Ascaris lumbricoides*.

4.1.1.7 Environmental - Wetlands

Review of existing reuse regulations show only three states (Arizona, Florida and South Dakota) with regulations pertaining to the use of reclaimed water for creation of artificial wetlands and/or the enhancement of natural wetlands.

South Dakota, whose regulations apply only to creation of artificial wetlands, require pretreatment with stabilization ponds prior to delivery to artificial wetlands. Florida has comprehensive and complex rules governing the discharge of reclaimed water to wetlands. Treatment and disinfection levels are established for different types of wetlands, different types of uses, and the degree of public access. Most wetland systems in Florida are used for additional treatment and only wetland restoration projects are considered reuse. Arizona does not specify the level of treatment required, but requires that the pH remain between 6.5 - 8.6, the dissolved oxygen in the receiving water not drop below 6 mg/L, and the mean fecal coliform count not exceed 1,000/100 mL, with no single sample exceeding 4,000/100 mL. Arizona also requires that the temperature of the reclaimed water shall not interfere with aquatic life and wildlife in the wetland system.

4.1.1.8 Industrial Reuse

Based on review of the existing reuse regulations, five states (Hawaii, Nevada, Oregon, Texas, and Utah) have regulations pertaining to industrial reuse of reclaimed water.

Nevada requires a minimum of secondary treatment and disinfection, with the mean fecal coliform count not to exceed 200/100 mL and no single sample exceeding 400/100 mL. Oregon requires biological treatment and disinfection, with the median total coliform count not to exceed 23/100 mL and no two consecutive samples exceeding 240/100 mL. Texas requires that the BOD not exceed 30 mg/L with treatment using a pond system and 20 mg/L with treatment other than a pond system. Texas also requires that the fecal coliform count not exceed 200/100 mL. Elsewhere, Utah requires advanced treatment, with the BOD not exceeding 10 mg/L at any time, TSS not exceeding 5 mg/L at any time, and the total coliform count not exceeding 3/100 mL at any time.

In addition to a total coliform count not to exceed 23/100 mL for a single sample, the state of Hawaii has set limits for enteric viruses when reclaimed water is used for industrial cooling water. The allowable limit for enteric

viruses is 1 pfu/40 L. Hawaii also requires that reclaimed water used for industrial cooling be treated with biocide or other disinfection agent to prevent viability of *Legionella* and *Klebsiella*.

4.1.2 Reclaimed Water Monitoring Requirements

Reclaimed water monitoring requirements vary greatly from state to state and again depend on the type of reuse. For unrestricted urban reuse, Arizona requires sampling for fecal coliform daily, while for agricultural reuse of non-food crops sampling for fecal coliform is only required once a month. Arizona also requires that turbidity be monitored on a continuous basis when a limit on turbidity is specified.

California, Florida, and Washington also require the continuous on-line monitoring of turbidity. Oregon, on the other hand, requires that turbidity be monitored hourly for unrestricted urban and recreational reuse as well as agricultural reuse on food crops and sampling for total coliform be conducted either once a day or once a week, depending on the type of reuse application.

Washington requires continuous on-line turbidity monitoring for agricultural reuse on food crops, while California requires that total coliform samples be taken on a daily basis and turbidity be monitored on a continuous basis for unrestricted urban and recreational reuse, as well as agricultural reuse on food crops. For unrestricted and restricted urban reuse, as well as agricultural reuse on food crops, Florida requires the continuous on-line monitoring of turbidity and chlorine residual. Even though no limits on turbidity are specified in Florida, continuous monitoring serves as an on-line surrogate for SS. In addition, Florida requires that the TSS limit must be achieved prior to disinfection and that fecal coliform samples be taken daily for treatment facilities with capacities greater than 0.5 mgd (22 L/s). Florida also requires an annual analysis of primary and secondary drinking water standards for reclaimed water used in irrigation. Other states determine monitoring requirements on a case-by-case basis depending on the type of reuse.

4.1.3 Treatment Facility Reliability

Some states have adopted facility reliability regulations or guidelines in place of, or in addition to, water quality requirements. Generally, requirements consist of alarms warning of power failure or failure of essential unit processes, automatic stand-by power sources, emergency storage, and the provision that each treatment process be equipped with multiple units or a back-up unit.

Articles 8, 9, and 10 of California's Title 22 regulations provide design and operational considerations covering alarms, power supply, emergency storage and disposal, treatment processes, and chemical supply, storage and feed facilities. For treatment processes, a variety of reliability features are acceptable in California. For example, for biological treatment, it is required that all biological treatment processes be provided with one of the following:

- Alarm (failure and power loss) and multiple units capable of producing biologically oxidized wastewater with one unit not in operation.
- Alarm (failure and power loss) and short-term (24-hour) storage or disposal provisions and stand-by replacement equipment.
- Alarm (failure and power loss) and long-term (20 days) storage or disposal provisions.

Florida requires Class I reliability of its treatment facilities when reclaimed water is used for irrigation of food crops and restricted and unrestricted urban reuse. Class I reliability requires multiple treatment units or back-up units and a secondary power source. In addition, a minimum of 1 day of reject storage is required to store reclaimed water of unacceptable quality for additional treatment. Florida also requires staffing at the water reclamation facility 24 hours/day, 7 days/week or 6 hours/day, 7 days/week as long as reclaimed water is delivered to the reuse system only during periods when a qualified operator is present; however, operator presence can be reduced to 6 hours/day if additional reliability features are provided.

Florida has also established minimum system sizes for treatment facilities to aid in assuring the continuous production of high-quality reclaimed water. Minimum system size for unrestricted and restricted urban reuse is 0.1 mgd (4 L/s), with the exception of residential lawn irrigation, which is 0.5 mgd (22 L/s). A minimum system size of 0.5 mgd (22 L/s) is also required for edible crop irrigation, with the exception of citrus irrigation under restricted access conditions, which is 0.1 mgd (4 L/s).

In South Carolina, operator presence is required 24 hr/d, 7 days/week and a minimum system size of 1.0 mgd (44 L/s) is required. In addition, South Carolina requires a back-up effluent disposal system for inclement weather or unusual operating conditions.

Other states which have regulations or guidelines regarding treatment facility reliability include Hawaii, North Carolina, Oregon, and Washington. Washington's

guidelines pertaining to treatment facility reliability are similar to California's regulations. Both Oregon and North Carolina require that multiple treatment units be provided for all essential treatment processes and a secondary or back-up power source be supplied.

4.1.4 Minimum Storage Requirements

Current regulations regarding storage requirements are primarily based upon the need to limit or prevent surface water discharge and are not related to storage required to meet diurnal or seasonal variations in supply and demand. Storage requirements vary from state to state and are generally dependent upon geographic location and site conditions. For example, Arizona requires a minimum storage volume equal to 5 days of the average design flow, while South Dakota requires a minimum storage volume of 210 days of the average design flow. The large difference is primarily due to the high number of non-irrigation days due to freezing temperatures in the northern states.

Most states that specify storage requirements do not differentiate between operational and seasonal storage, with the exception of Georgia and Delaware, which require that both operational and wet weather storage be considered. The majority of states that have storage requirements in their regulations require that a water balance be performed on the reuse system, taking into account all inputs and outputs of water to the system based on a specified rainfall recurrence interval. For example, in addition to the minimum storage requirement of 60 days, Maryland also requires that a water balance be performed based on a 1-in-10 year rainfall recurrence interval to determine if additional storage is required beyond the minimum requirement of 60 days.

Texas, on the other hand, requires that a water balance be performed based on average rainfall conditions, while Illinois requires that a water balance be performed based on a 1-in-20 year rainfall recurrence interval to determine if storage beyond the minimum requirement of 150 days is needed.

4.1.5 Application Rates

When regulations specify application or hydraulic loading rates, the regulations generally pertain to land application systems that are used primarily for additional wastewater treatment for disposal rather than reuse. When systems are developed chiefly for the purpose of land treatment and/or disposal, the objective is often to dispose of as much effluent on as little land as possible; thus, application rates are often far greater than irrigation demands and limits are set for the maximum hydraulic loading. On the other hand, when the reclaimed water is managed as a valuable resource, the objective is to apply the water according to irrigation needs rather than maximum hydraulic loading, and application limits are rarely specified.

Many states do not have any specific requirements regarding reclaimed water application rates, as these are generally based on site conditions; however, some states require that the hydraulic loading rate not exceed 2.0 to 2.5 in (51-64 mm)/week. Nebraska's guidelines suggest that hydraulic loading rates not exceed 4.0 in (102 mm)/ week.

In addition to hydraulic loading rates, some states also have limits on nitrogen loading. For example, Georgia and Delaware both require that the effluent percolating from the reuse system have a nitrate-nitrogen concentration of 10 mg/L or less, while Missouri and Nebraska both require that the nitrogen loading not exceed the nitrogen uptake of the crop.

4.1.6 Groundwater Monitoring

Groundwater monitoring programs associated with irrigation of reclaimed water are required by Arkansas, Delaware, Florida, Georgia, Illinois, Maryland, Missouri, South Carolina, Washington, Wisconsin, West Virginia, New Jersey, Hawaii, Tennessee, and Montana. In general, these groundwater monitoring programs require that one well be placed hydraulically upgradient of the reuse site to assess background and incoming groundwater conditions within the aquifer in question and two wells be placed hydraulically downgradient of the reuse sites. Groundwater monitoring programs associated with reclaimed water irrigation generally focus on water quality in the surficial aquifer. Groundwater monitoring programs associated with reclaimed water irrigation generally focus on water quality in the surficial aquifer. Florida generally requires a minimum of three monitoring wells at each reuse site. Some states also require that a well be placed within each reuse site. South Carolina's guidelines suggest that a minimum of 9 wells be placed in golf courses (18-holes) that irrigate with reclaimed water. Sampling parameters and frequency of sampling are generally considered on a case-by-case basis.

4.1.7 Setback Distances for Irrigation

Many states have established setback distances or buffer zones between reuse irrigation sites and various facilities such as potable water supply wells, property lines, residential areas, and roadways. Setback distances vary depending on the quality of reclaimed water and the method of application. For example, Illinois requires a 50-ft (15 m) setback from the edge of the wetted perimeter of the reuse site to a residential lot for a non-spray application system, but requires a 150-ft (45-m) setback

for a spray irrigation system. For restricted and unrestricted urban reuse and irrigation of food crops, Florida requires a 75-ft (23-m) setback to potable water supply wells; but for agricultural reuse on non-food crops, Florida requires a 500-ft (150-m) setback to potable water supply wells and a 100-ft (30-m) setback to property lines. Florida will allow reduced setback distances for agricultural reuse on non-food crops if additional facility reliability and treatment are provided. Colorado recommends a 500-ft (150-m) setback distance to domestic supply wells and a 100-ft (30-m) setback to any irrigation well regardless of the quality of the reclaimed water.

Oregon and Nevada do not require setback distances when reclaimed water is used for unrestricted urban reuse or irrigation of food crops due to the high degree of treatment required; however, setback distances are required for irrigation of non-food crops and restricted urban reuse. In Nevada, the quality requirements for reclaimed water are based not only on the type of reuse, but also on the setback distance. For example, for restricted urban reuse and a 100-ft (30-m) buffer zone, Nevada requires that the reclaimed water have a mean fecal coliform count of no more than 23/100 mL and a turbidity of no more than 5 NTU. However, with no buffer zone, the reclaimed water must have a mean fecal coliform count of no more than 2.2/100 mL and a turbidity of no more than 3 NTU.

4.2 Suggested Guidelines for Water Reuse

Table 28 presents suggested wastewater treatment processes, reclaimed water quality, monitoring, and setback distances for various types of water reuse. Suggested guidelines are presented for the following categories:

- Urban Reuse
- Restricted Access Area Irrigation
- Agricultural Reuse - Food Crops
  - Food crops not commercially processed
  - Commercially processed food crops and surface irrigation of orchards and vineyards
- Agricultural Reuse - Non Food Crops
  - Pasture for milking animals and fodder, fiber, and seed crops
- Recreational Impoundments
- Landscape Impoundments
- Construction Uses
- Industrial Reuse
- Environmental Reuse
- Groundwater Recharge
  - Spreading or injection into nonpotable aquifer
- Indirect Potable Reuse
  - Spreading into potable aquifer
  - Injection into potable aquifer
  - Augmentation of surface supplies

These guidelines apply to domestic wastewater from municipal or other wastewater treatment facilities having a limited input of industrial waste. The suggested guidelines are predicated principally on water reclamation and reuse information from the U.S. and are intended to apply to reclamation and reuse facilities in the U.S. Local conditions may limit the applicability of these guidelines in some countries (see Chapter 8). It is explicitly stated that the direct application of these suggested guidelines will not be used by AID as strict criteria for funding.

The suggested treatment processes, reclaimed water quality, monitoring frequency, and setback distances are based on:

- Water reuse experience in the U.S. and elsewhere;
- Research and pilot plant or demonstration study data;
- Technical material from the literature;
- Various states' reuse regulations, policies, or guidelines (see Appendix A);
- Attainability; and
- Sound engineering practice.

These guidelines are not intended to be used as definitive water reclamation and reuse criteria. They are intended to provide reasonable guidance for water reuse opportunities, particularly in states that have not developed their own criteria or guidelines.

Adverse health consequences associated with the reuse of raw or improperly treated wastewater are well documented (Lund, 1980; Feachem *et al.*, 1983, Shuval *et al.*, 1986). As a consequence, water reuse standards and guidelines are principally directed at public health

Table 28. **Suggested Guidelines for Water Reuse [1] (Page 1 of 6)**

Types of Reuse	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Setback Distances [3]	Comments
Urban Reuse All types of landscape irrigation, (e.g., golf courses, parks, cemeteries) —also vehicle washing, toilet flushing, use in fire protection systems and commercial air conditioners, and other uses with similar access or exposure to the water	• Secondary [4] • Filtration [5] • Disinfection [6]	• pH = 6 - 9 • ≤ 10 mg/l BOD [7] • ≤ 2 NTU [8] • No detectable fecal coli/100 ml [9,10] • 1 mg/l Cl_2 residual (min.) [11]	• pH - weekly • BOD - weekly • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous	• 50 ft (15 m) to potable water supply wells	• See Table 19 for other recommended limits. • At controlled-access irrigation sites where design and operational measures significantly reduce the potential of public contact with reclaimed water, a lower level of treatment, e.g., secondary treatment and disinfection to achieve ≤ 14 fecal coli/100 ml, may be appropriate. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of pathogens. [12] • Reclaimed water should be clear, odorless, and contain no substances that are toxic upon ingestion. • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • A chlorine residual of 0.5 mg/l or greater in the distribution system is recommended to reduce odors, slime, and bacterial regrowth. • See Section 2.4.3. for recommended treatment reliability.
Restricted Access Area Irrigation Sod farms, silviculture sites, and other areas where public access is prohibited, restricted, or infrequent	• Secondary [4] • Disinfection [6]	• pH = 6 - 9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (min.) [11]	• pH - weekly • BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to potable water supply wells • 100 ft (30 m) to areas accessible to the public (if spray irrigation)	• See Table 19 for other recommended limits. • If spray irrigation, SS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • See Section 2.4.3 for recommended treatment reliability.
Agricultural Reuse - Food Crops Not Commercially Processed [15] Surface or spray irrigation of any food crop, including crops eaten raw.	• Secondary [4] • Filtration [5] • Disinfection [6]	• pH = 6 - 9 • ≤ 10 mg/l BOD [7] • ≤ 2 NTU [8] • No detectable fecal coli/100 ml [9,10] • 1 mg/l Cl_2 residual (min.) [11]	• pH - weekly • BOD - weekly • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous	• 50 ft (15 m) to potable water supply wells	• See Table 19 for other recommended limits. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of pathogens. [12] • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • High nutrient levels may adversely affect some crops during certain growth stages. • See Section 2.4.3 for recommended treatment reliability.

Table 28. **Suggested Guidelines for Water Reuse [1] (Page 2 of 6)**

Types of Reuse	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Setback Distances [3]	Comments
Agricultural Reuse - Food Crops Commercially Processed ;[15] Surface Irrigation of Orchards and Vineyards	• Secondary [4] • Disinfection [6]	• pH = 6 - 9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (min.) [11]	• pH - weekly • BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to potable water supply wells • 100 ft (30 m) to areas accessible to the public	• See Table 19 for other recommended limits. • If spray irrigation, SS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • High nutrient levels may adversely affect some crops during certain growth stages. • See Section 2.4.3 for recommended treatment reliability.
Agricultural Reuse - Non-Food Crops Pasture for milking animals; fodder, fiber and seed crops	• Secondary [4] • Disinfection [6]	• pH = 6 - 9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (min.) [11]	• pH - weekly • BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to potable water supply wells • 100 ft (30 m) to areas accessible to the public (if spray irrigation)	• See Table 19 for other recommended limits. • If spray irrigation, SS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • High nutrient levels may adversely affect some crops during certain growth periods. • Milking animals should be prohibited from grazing for 15 days after irrigation ceases. A higher level of disinfection, e.g., to achieve ≤14 fecal coli/100 ml, should be provided if this waiting period is not adhered to. • See Section 2.4.3 for recommended treatment reliability.
Recreational Impoundments Incidental contact (e.g., fishing and boating) and full body contact with reclaimed water allowed	• Secondary [4] • Filtration [5] • Disinfection [6]	• pH = 6 - 9 • ≤ 10 mg/l BOD [7] • ≤2 NTU [8] • No detectable fecal coli/100 ml [9,10] • 1 mg/l Cl_2 residual (min.) [11]	• pH - weekly • BOD - weekly • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous	• 500 ft (150 m) to potable water supply wells (minimum) if bottom not sealed	• Dechlorination may be necessary to protect aquatic species of flora and fauna. • Reclaimed water should be non-irritating to skin and eyes. • Reclaimed water should be clear, odorless, and contain no substances that are toxic upon ingestion. • Nutrient removal may be necessary to avoid algae growth in impoundments. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of pathogens. [12] • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • Fish caught in impoundments can be consumed. • See Section 2.4.3 for recommended treatment reliability.

Table 28. **Suggested Guidelines for Water Reuse[1]** (Page 3 of 6)

Types of Reuse	Treatment	Reclaimed Water Quality[2]	Reclaimed Water Monitoring	Setback Distances[3]	Comments
Landscape Impoundments Aesthetic impoundment where public contact with reclaimed water is not allowed	• Secondary[4] • Disinfection[6]	• ≤ 30 mg/l BOD[7] • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml[9,13,14] • 1 mg/l Cl_2 residual (min.)[11]	• pH - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous	• 500 ft (150 m) to potable water supply wells (minimum) if bottom not sealed	• Nutrient removal processes may be necessary to avoid algae growth in impoundments. • Dechlorination may be necessary to protect aquatic species of flora and fauna. • See Section 2.4.3 for recommended treatment reliability.
Construction Uses Soil compaction, dust control, washing aggregate, making concrete	• Secondary[4] • Disinfection[6]	• ≤ 30 mg/l BOD • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml[9,13,14] • 1 mg/l Cl_2 residual (min.)[11]	• BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous		• Worker contact with reclaimed water should be minimized. • A higher level of disinfection, e.g., to achieve ≤ 14 fecal coli/100 ml, should be provided where frequent worker contact with reclaimed water is likely. • See Section 2.4.3 for recommended treatment reliability.
Industrial Reuse Once-through cooling	• Secondary[4]	• pH = 6 - 9 • ≤ 30 mg/l BOD[7] • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml[9,13,14] • 1 mg/l Cl_2 residual (min.)[11]	• pH - daily • BOD - weekly • SS - weekly • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to areas accessible to the public	• Windblown spray should not reach areas accessible to users or the public.
Recirculating cooling towers	• Secondary[4] • Disinfection[6] (chemical coagulation and filtration[5] may be needed)	• Variable, depends on recirculation ratio (see Section 3.3.1)		• 300 ft (90 m) to areas accessible to the public. May be reduced if high level of disinfection is provided.	• Windblown spray should not reach areas accessible to the public. • See Table 13 for additional recommended limits. • Additional treatment by user is usually provided to prevent scaling, corrosion, biological growths, fouling and foaming. • See Section 2.4.3 for recommended treatment reliability.
Other Industrial Uses	← Depends on site specific use (See Sections 3.3.2 and 3.3.3) →				
Environmental Reuse Wetlands, marshes, wildlife habitat, stream augmentation	• Variable • Secondary[4] and disinfection[6] (min.)	Variable, but not to exceed: • ≤ 30 mg/l BOD[7] • ≤ 30 mg/l SS • ≤ 200 fecal coli/100 ml[9,13,14]	• BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous		• Dechlorination may be necessary to protect aquatic species of flora and fauna. • Possible effects on groundwater should be evaluated. • Receiving water quality requirements may necessitate additional treatment. • The temperature of the reclaimed water should not adversely affect ecosystem. • See Section 2.4.3 for recommended treatment reliability.

Table 28. Suggested Guidelines for Water Reuse[1] (Page 4 of 6)

Types of Reuse	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Distance to Point of Withdrawal	Comments
Groundwater Recharge By spreading or injection into nonpotable aquifers	• Site specific and use dependent • Primary (min.) for spreading • Secondary[4] (min.) for injection	• Site specific and use dependent	• Depends on treatment and use	• Site specific	• Facility should be designed to ensure that no reclaimed water reaches potable water supply aquifers. • See Section 3.6 for more information. • For injection projects, filtration and disinfection may be needed to prevent clogging. • See Section 2.4.3 for recommended treatment reliability.
Indirect Potable Reuse Groundwater recharge by spreading into potable aquifers	• Site specific • Secondary[4] and disinfection[6] (min.) May also need filtration[5] and/or advanced wastewater treatment[16]	• Site specific • Meet drinking water standards after percolation through vadose zone	Includes, but not limited to, the following: • pH - daily • Coliform - daily • Cl_2 residual - continuous • Drinking water standards - quarterly • Other[17] - depends on constituent	• 2000 ft (600 m) to extraction wells. May vary depending on treatment provided and site-specific conditions.	• The depth to groundwater (i.e., thickness of the vadose zone) should be at least 6 feet (2m) at the maximum groundwater mounding point. • The reclaimed water should be retained underground for at least 1 year prior to withdrawal. • Recommended treatment is site-specific and depends on factors such as type of soil, percolation rate, thickness of vadose zone, native groundwater quality, and dilution. • Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. • See Sections 3.6 and 3.7 for more information. • The reclaimed water should not contain measurable levels of pathogens after percolation through the vadose zone.[12] • See Section 2.4.3. for recommended treatment reliability.
Groundwater recharge by injection into potable aquifers	• Secondary[4] • Filtration[5] • Disinfection[6] • Advanced wastewater treatment[16]	Includes, but not limited to, the following: • pH = 6.5 - 8.5 • ≤ 2 NTU[8] • No detectable fecal coli/100 ml[9,10] • 1 mg/l Cl_2 residual (min.)[11] • Meet drinking water standards	Includes, but not limited to, the following: • pH - daily • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous • Drinking water standards - quarterly • Other[17] depends on constituent	• 2000 ft (600m) to extraction wells. May vary depending on site-specific conditions.	• The reclaimed water should be retained underground for at least 1 year prior to withdrawal. • Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. • Recommended quality limits should be met at the point of injection. • The reclaimed water should not contain measurable levels of pathogens at the point of injection.[12] • See Sections 3.6 and 3.7 for more information. • A higher chlorine residual and/or a longer contact time may be necessary to assure virus inactivation. • See Section 2.4.3. for recommended treatment reliability.

Table 28. Suggested Guidelines for Water Reuse[1] (Page 5 of 6)

Types of Reuse	Treatment	Reclaimed Water Quality[2]	Reclaimed Water Monitoring	Distance to Point of Withdrawal	Comments
Indirect Potable Reuse Augmentation of surface supplies	• Secondary [4] • Filtration [5] • Disinfection [6] • Advanced wastewater treatment[16]	Includes, but not limited to, the following: • pH = 6.5 - 8.5 • ≤ 2 NTU[8] • No detectable fecal coli/100 ml[9,10] • 1 mg/l Cl_2 residual (min.)[11] • Meet drinking water standards	Includes, but not limited to, the following: • pH - daily • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous • Drinking water standards - quarterly • Other[17] - depends on constituent	• Site specific	• Recommended level of treatment is site-specific and depends on factors such as receiving water quality, time and distance to point of withdrawal, dilution and subsequent treatment prior to distribution for potable uses. • The reclaimed water should not contain measurable levels of pathogens. [12] • See Section 3.7 for more information. • A higher chlorine residual and/or a longer contact time may be necessary to assure virus inactivation. • See Section 2.4.3 for recommended treatment reliability.

Table 28. Suggested Guidelines for Water Reuse[1] (Page 6 of 6)

Footnotes

[1] These guidelines are based on water reclamation and reuse practices in the U.S., and they are especially directed at states that have not developed their own regulations or guidelines. While the guidelines should be useful in many areas outside the U.S., local conditions may limit the applicability of the guidelines in some countries (see Chapter 8). It is explicitly stated that the direct application of these suggested guidelines will not be used by AID as strict criteria for funding.

[2] Unless otherwise noted, recommended quality limits apply to the reclaimed water at the point of discharge from the treatment facility.

[3] Setback distances are recommended to protect potable water supply sources from contamination and to protect humans from unreasonable health risks due to exposure to reclaimed water.

[4] Secondary treatment processes include activated sludge processes, trickling filters, rotating biological contactors, and many stabilization pond systems. Secondary treatment should produce effluent in which both the BOD and SS do not exceed 30 mg/l.

[5] Filtration means the passing of wastewater through natural undisturbed soils or filter media such as sand and/or anthracite.

[6] Disinfection means the destruction, inactivation, or removal of pathogenic microorganisms by chemical, physical, or biological means. Disinfection may be accomplished by chlorination, ozonation, other chemical disinfectants, UV radiation, membrane processes, or other processes.

[7] As determined from the 5-day BOD test.

[8] The recommended turbidity limit should be met prior to disinfection. The average turbidity should be based on a 24-hour time period. The turbidity should not exceed 5 NTU at any time. If SS is used in lieu of turbidity, the average SS should not exceed 5 mg/l.

[9] Unless otherwise noted, recommended coliform limits are median values determined from the bacteriological results of the last 7 days for which analyses have been completed. Either the membrane filter or fermentation tube technique may be used.

[10] The number of fecal coliform organisms should not exceed 14/100 ml in any sample.

[11] Total chlorine residual after a minimum contact time of 30 minutes.

[12] It is advisable to fully characterize the microbiological quality of the reclaimed water prior to implementation of a reuse program.

[13] The number of fecal coliform organisms should not exceed 800/100 ml in any sample.

[14] Some stabilization pond systems may be able to meet this coliform limit without disinfection.

[15] Commercially processed food crops are those that, prior to sale to the public or others, have undergone chemical or physical processing sufficient to destroy pathogens.

[16] Advanced wastewater treatment processes include chemical clarification, carbon adsorption, reverse osmosis and other membrane processes, air stripping, ultrafiltration, and ion exchange.

[17] Monitoring should include inorganic and organic compounds, or classes of compounds, that are known or suspected to be toxic, carcinogenic, teratogenic, or mutagenic and are not included in the drinking water standards.

protection and generally are based on the control of pathogenic organisms. These guidelines address health protection via suggested wastewater treatment unit processes, reclaimed water quality limits, and other controls (setback distances, etc.).

Both treatment processes and water quality limits are recommended for the following reasons:

- Water quality criteria that include the use of surrogate parameters may not adequately characterize reclaimed water quality;
- A combination of treatment and quality requirements known to produce reclaimed water of acceptable quality obviate the need to monitor the finished water for certain constituents, e.g., some health-significant chemical constituents or pathogenic microorganisms;
- Expensive, time-consuming, and, in some cases, questionable monitoring for pathogenic organisms, such as viruses, is eliminated without compromising health protection; and
- Treatment reliability is enhanced.

It would be impractical to monitor reclaimed water for all of the chemical constituents and pathogenic organisms of concern, and surrogate parameters are universally accepted. In the U.S., total and fecal coliforms are the most commonly used indicator organisms in reclaimed water. The total coliform analysis includes enumeration of organisms of both fecal and nonfecal origin, while the fecal coliform analysis is specific for coliform organisms of fecal origin. Therefore, fecal coliforms are better indicators of fecal contamination than total coliforms, and these guidelines use fecal coliform as the indicator organism. Either the multiple-tube fermentation technique or the membrane filter technique may be used to quantify the coliform levels in the reclaimed water.

These guidelines do not include suggested parasite or virus limits. Parasites have not been shown to be a problem at water reuse operations in the U.S. at the treatment and quality limits recommended in these guidelines. Viruses are of concern in reclaimed water, but virus limits are not recommended in these guidelines for the following reasons:

- A significant body of information exists indicating that viruses are reduced or inactivated to low or immeasurable levels via appropriate wastewater treatment, including filtration and disinfection (Sanitation Districts of Los Angeles County, 1977; Engineering-Science, 1987; Crook, 1989);
- The identification and enumeration of viruses in wastewater are hampered by relatively low virus recovery rates, the complexity and high cost of laboratory procedures, and the limited number of facilities having the personnel and equipment necessary to perform the analyses;
- The laboratory culturing procedure to determine the presence or absence of viruses in a water sample takes about 14 days, and another 14 days are required to identify the viruses;
- There is no consensus among virus experts regarding the health significance of low levels of viruses in reclaimed water; and
- There have been no documented cases of viral disease resulting from the reuse of wastewater at any of the water reuse operations in the U.S.

The removal of suspended matter is related to the virus issue. It is known that many pathogens are particulate-associated and that particulate matter can shield both bacteria and viruses from disinfectants. Also, organic matter consumes chlorine, thus making less of the disinfectant available for disinfection. There is general agreement that particulate matter should be reduced to low levels, e.g., 2 NTU or 5 mg/L SS, prior to disinfection to ensure reliable destruction of pathogenic microorganisms during the disinfection process. Suspended solids measurements are typically performed daily on a composite sample and only reflect an average value. Continuously monitored turbidity is superior to daily SS measurements as an aid to treatment operation.

The need to remove organic matter is related to the type of reuse. Some of the adverse effects associated with organic substances are that they are aesthetically displeasing (may be malodorous and impart color), provide food for microorganisms, adversely affect disinfection processes, and consume oxygen. The recommended BOD limit is intended to indicate that the organic matter has been stabilized, is nonputrescible, and has been lowered to levels commensurate with anticipated types of reuse. SS limits are suggested as a measure of organic and inorganic particulate matter in reclaimed water that has received secondary treatment. The recommended BOD and SS limits are readily achievable at well operated water reclamation plants.

The suggested setback distances are somewhat subjective. They are intended to protect drinking water

supplies from contamination and, where appropriate, to protect humans from exposure to the reclaimed water. While studies indicate the health risk associated with aerosols from spray irrigation sites using reclaimed water is low (EPA, 1980), the general practice is to limit, through design or operational controls, exposure to aerosols and windblown spray produced from reclaimed water that is not highly disinfected.

Unplanned or incidental indirect potable reuse occurs in many states in the U.S., while planned or intentional indirect potable reuse via groundwater recharge or augmentation of surface supplies is a less-widely accepted practice. Whereas the water quality requirements for nonpotable water uses are tractable and not likely to change significantly in the future, the number of water quality constituents to be monitored in drinking water (and, hence, reclaimed water intended for potable reuse) will increase and quality requirements will become more restrictive. Consequently, it would not be prudent to suggest a complete list of reclaimed water quality limits for all constituents of concern. Some general and specific information is provided in the guidelines to indicate the extensive treatment, water quality, and other requirements that are likely to be imposed where indirect potable reuse is contemplated.

4.3 References

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